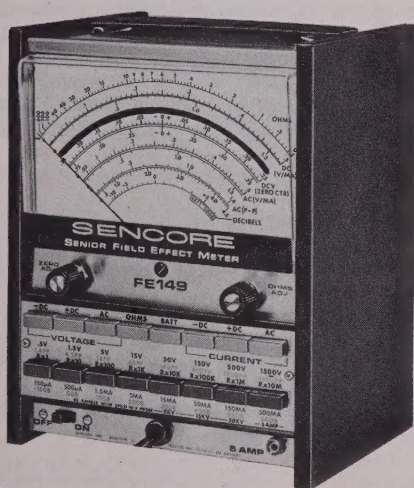


FE 149

SENIOR FIELD
EFFECT METER

S E N I O R F E L D M E T E R



SENCORE SERVICE MANUAL

426 S. WESTGATE DRIVE, ADDISON, ILLINOIS

Safety Precautions

When testing electronic equipment, there is always a danger present. Unexpected high voltages can be present at unusual locations in defective equipment. The technician should become familiar with the device that he is working on and observe the following precautions.

1. An isolation transformer should always be used on equipment having the chassis tied to one side of the AC power line.
2. When making test lead connections to high voltage points, remove the power. If this cannot be done, be sure to avoid contact with other equipment or metal objects. Place one hand in your pocket as a safety precaution and stand on an insulated floor to reduce the possibility of shock.
3. Discharge filter capacitors before connecting test leads to them. Capacitors can store a charge that could be dangerous to the technician.
4. Be sure your equipment is in good order. Broken or frayed test leads can be extremely dangerous and can expose the technician to dangerous potentials.
5. Remove the test leads immediately after the test has been completed to reduce the possibility of shock.
6. Do not work alone when working on hazardous circuits. Always have another person close by in case of accident. Remember, even a minor shock can be the cause of a more serious accident, such as falling against the equipment, or coming in contact with higher voltages.

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INSTRUCTION MANUAL FOR THE SENCORE FE149 SENIOR FIELD EFFECT METER

The Sencore FE149 Senior Field Effect Meter is a revolutionary concept in meters. It takes the advantages of the VTVM and the VOM and the ease of push buttons to make one of the most versatile meters for the electronics industry. High input impedance on both the AC and DC ranges, peak to peak AC measurements, AC and DC current ranges, zero center DC ranges and zero warm up time make this the ideal meter for any phase of the electronic industry.

No other meter in the FE149 class has all these features combined into one instrument:

- * High input impedance on both AC and DC voltage ranges of 15 megohms
- * Push button range and function selection for ease and speed
- * True peak to peak on AC ranges
- * Zero center DC ranges for solid state servicing
- * DC and AC current ranges for general testing
- * DB ranges for audio and lab work
- * Mirrored scale meter for greatest accuracy in readings
- * Meter protected from overloads
- * Circuits protected from accidental application of wrong voltages
- * All steel construction for greater durability
- * 3-way power; battery, AC line, or AC line while charging the battery

FE149 SPECIFICATIONS

DC VOLTS

Ranges 0 to .5, 1.5, 5, 50, 150, 500, 1500 full scale
-.25 to .25, -.75 to .75, -2.5 to 2.5, -7.5 to 7.5,
-25 to 25, -75 to 75, -250 to 250, and -750 to 750 ZERO
CENTER RANGES

Input Resistance: 15 megohms shunted by 45 pf

Accuracy: $\pm 1.5\%$

AC Rejection: 30 db

AC VOLTS

Ranges: RMS

0 to .5, 1.5, 5, 15, 50, 150, 500, and 1500 full scale

Ranges: Peak to Peak

0 to 1.4, 4.5, 14, 45, 140, 450, 1400, and 4500 full scale

Frequency compensated

Input Resistance: 15 megohms shunted by 125 pf

Frequency Response: Flat: 25Hz to 1 MHz

3 db points 8 Hz to over 8 MHz

Accuracy: $\pm 3\%$

OHMMETER

Ranges: 0 to 600 ohms, 6,000, 60K, 600K, 6 meg, 60 meg, 600 meg,
and 6,000 megs

Accuracy: $\pm 1\frac{1}{2}$ degree arc

DC CURRENT MEASUREMENTS

Ranges: 0 to 150 microamps, 500 microamps, 1.5 Ma, 5 Ma, 15 Ma,
50 Ma, 150 Ma, and 500 Ma.

5 amps thru special jack on front panel

Accuracy: $\pm 3\%$ full scale

Internal Voltage Drop: 300 MV on 150 Microamp to 15 Ma; 340 MV on 50 Ma,
425 MV on 150 Ma, and 720 MV on 500 Ma, 880 MV
at 5 Amp Jack

AC CURRENT MEASUREMENTS

Ranges: 0 to 150 microamps, 500 microamps, 1.5 Ma, 5 Ma, 15 Ma,
50 Ma, 150 Ma, and 500 Ma

5 amps thru special jack on front panel

Accuracy: $\pm 3\%$ full scale

Internal Voltage Drop: 300 MV on 150 Microamp to 15 Ma; 340 MV on 50 Ma,
425 MV on 150 Ma and 720 MV on 500 Ma, 880 MV at
5 Amp Jack

DECIBELS

Ranges: -10, 0, 10, 20, 30, 40, 50, and 60 db

Reference: 1 MW into 600 ohms

GENERAL

Meter: 7", 100 microamp $\pm 2\%$, diode protected and isolated from the input

Multiplier Resistors: $1/2\%$ precision type

Ohms Battery: 1.5 volt "D" cell (Not supplied)

Power: Internal 9.6 volt rechargeable battery (Not supplied) or 105 to 130 volt
AC line, 50 to 60 Hertz.

Weight: (less batteries): 6 pounds.

Dimensions: 9" x 7 $1/2$ " x 6"

Optional Accessories: High Voltage probe (39A21) extends ranges to 50 KV

CONTROLS ON THE FE149

The FE149 is extremely simple and easy to operate. Panel controls include the push button RANGE and FUNCTION switches, meter ZERO ADJ, OHMS ADJ, and the OFF-ON switch. The following is a brief description of each control and how it is used.

OFF-ON switch: The OFF-ON switch controls the power to the circuit in the FE149 and its recharging system. In the OFF position, the battery is disconnected from the circuit and the power to the transformer is removed. In the ON position, the battery voltage is connected to the circuit and AC power is applied from the line to the transformer for the recharging system. A red fluorescent flag appears in the switch opening to indicate when the FE149 is on. When measuring DC current, the OFF-ON switch may be left in the OFF position as no power to the circuit is needed. When measuring AC current, the FE149 must be turned to the ON position as the internal circuit is used.

ZERO ADJ: The ZERO ADJ is used to position the pointer of the meter over the zero on the extreme left of the meter scale or to position the pointer on the center zero when using the zero center ranges of the FE149.

OHMS ADJ: The OHMS ADJ is the same as that found on most meters. Prior to measuring resistance, the FE149 leads are shorted together and the OHMS ADJ is rotated for a full scale deflection (zero ohms) as read on the ohms scale of the meter.

FUNCTION SWITCH: The FUNCTION SWITCH is a push button switch used to select the desired function for the measurements to be performed by the FE149. Simply push in the desired function, plus or minus DC volts, AC volts, Ohms, BATT check, plus or minus DC current or AC current, a total of 8 functions.

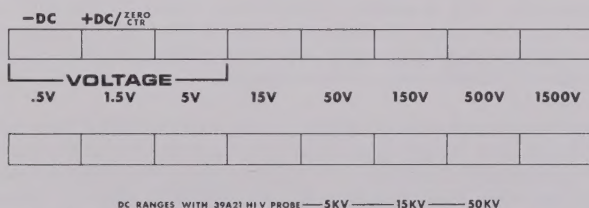
RANGE SWITCH: The RANGE SWITCH is a push button switch to select the desired range of current, voltage or resistance to be measured with the FE149. There are a total of 8 different ranges available on the FE149.

OPERATING THE FE149

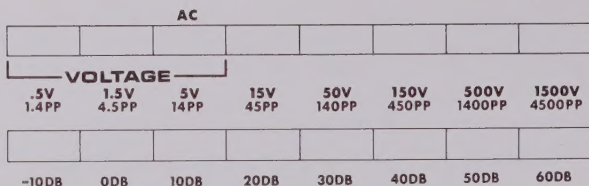
The Sencore FE149 Senior Field Effect Meter is extremely easy to operate. Simply depress the desired function button on the FUNCTION switch and depress the desired range button on the RANGE switch, connect the leads, and read the results on the meter. Here is a brief description of how each test is performed with the FE149.

READING DC VOLTS: To read DC volts on the FE149, depress either the minus DC or plus DC button on the FUNCTION switch. Depress the desired range button for the voltage to be measured from .5 volts to 1500 volts on the RANGE switch. If the voltage to be measured is unknown, start with one of the higher ranges to see how much voltage is present and depress the range button that will give the desired meter deflection. When measuring DC voltages in RF-IF circuits, a 100K resistor at the end of the probe lead will reduce the capacity loading effects and not upset the circuits for the most accurate readings.

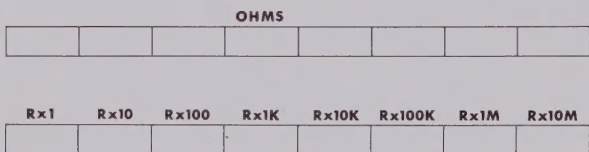
The DC voltage is read on the two black scales just above the mirror on the meter. The top DC scale is from zero to .5 volts and each mark is equal to .01 volts. The bottom scale is zero to 1.5 volts and each mark is equal to .02 volts. The zero to .5 scale is used for the .5, 5, 50, and 500 volt ranges and the zero to 1.5 scale is used for the 1.5, 15, 150, and 1500 volt ranges. In use, the meter indication is multiplied by 1, 10, 100, or 1000 depending upon the range. For example, if the 15 volt RANGE button is depressed and the meter reads .68 volts, the actual voltage is .68 times 10 or 6.8 volts DC.



READING DC VOLTS ZERO CENTER SCALE: The zero center scales are used to read plus or minus voltages without the necessity of changing polarity with the leads or Function switch. To use the zero center scales, depress the plus DC voltage function button and adjust the ZERO ADJ control until the meter pointer reads at the zero mark in the center of the scale. This is the scale directly below the mirror on the meter. This gives ranges of plus or minus zero to .25 volts (top scale) and plus or minus zero to .75 volts (bottom scale), times 10, 100, or 1000 depending upon the range button that is depressed. If the meter swings up scale or to the right, it is a positive voltage. If the meter swings down scale or to the left it is a negative voltage. This unique feature allows you to determine the polarity as well as the amplitude of a DC voltage and is very handy in solid state work.



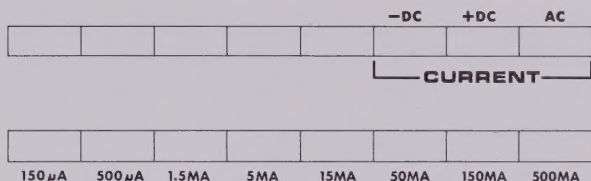
READING AC VOLTS: To read AC volts on the FE149, the AC voltage button on the FUNCTION switch and the desired button on the RANGE switch are depressed for the voltage to be measured. For RMS voltages the two black scales below the mirror on the meter marked AC (V/MA) are used. For peak to peak, the two red scales just below the AC RMS scales are used. The readings are multiplied in the same way as the DC scales to obtain the actual voltage present. On the zero to .5 scale, each mark is equal to .01 and on the zero to 1.5 each mark is equal to .05 volts. On the zero to 1.4 volts peak to peak scale, each mark is equal to .05 volts and on the zero to 4.5 volts peak to peak each mark is equal to .1 volts.



READING OHMS: To read resistance with your FE149, depress the OHMS button on the Function switch and depress the Range button for the desired resistance range to be measured. After checking to see that the meter is "zeroed" at the left edge of the scale, short the leads together and adjust the OHMS ADJ control for a full scale deflection of the meter or 0 ohms. Unshort the leads and be sure that the meter returns to the extreme left of the scale. Place the unknown resistance between the FE149 leads and read the resistance on the OHMS scale (top red scale on meter). Multiply the reading on the meter by the range used to obtain the actual value of resistance measured. For example, if the meter read 15 and the R X 100 Range button is depressed, the actual resistance would be 15 x 100 or 1500 ohms. NOTE: For greatest accuracy when using the R X 10 meg range it is best to make the meter zero adjust on the R X 1 meg range. Then depress the R X 10 meg button and make your measurement.

CAUTION: If you use an ohmmeter to check transistors, do not use the R X 1 range of the FE149. Because of the low resistance that the FE149 will measure, the current on this range may damage a transistor if used to check the front to back ratio of the junctions. Use the higher ranges such as the RX100 or above. A better check on transistors can be made by using a transistor tester such as the Sencore TR139, TR15A, or TF151. These testers will test the transistor both in and out of circuit without any possible damage to the circuit or transistor if accidentally connected wrong.

MEASURING DC CURRENT: To measure DC current, the plus or minus DC current button is depressed and the desired range button for the current range to be measured. The FE149 does not have to be turned on for the measurement of DC current and may be left in the off position if so desired. The leads of the FE149 are connected in series with the circuit being measured and the current read on the DC(V/MA) scale of the meter. For the 150 microamp, 1.5 Ma, 15Ma, and 150 Ma ranges, the 0 to 1.5 scale is used. For the 150 microamp range, the reading is multiplied by 100



and for the Ma ranges by 1, 10, and 100. For the 500 microamp, 5 Ma, 50 Ma, and 500 Ma ranges, the 0 to .5 scale is used. The readings are multiplied by 1000 for the 500 microamp range and by 10, 100, and 1000 for the Ma ranges. If the meter reads backwards when making current measurements, the leads are reversed. The meter polarity can be changed so that the meter reads in the proper direction by simply depressing the opposite polarity DC CURRENT button on the Range switch.

To use the special 5 amp range of the FE149, insert the red test lead supplied into the 5 A jack on the front panel. Depress the 500 Ma Range button and the plus or minus DC CURRENT button. Use the red lead from the 5A jack and the ground lead of the FE149. Do not use the probe lead for the 5 amp current measurements as it is not designed to carry 5 amperes of current. The 0 to .5 scale of the meter will be used and the readings multiplied by 10 to give the current in amps.

Be sure to remove the red lead from the 5A jack when making other measurements with the FE149. If the lead is left plugged into the 5A jack, errors in the other readings taken with the FE149 will result.

MEASURING AC CURRENT: To measure AC current, the leads of the FE149 are connected in series with the circuit where the current is to be measured and the AC CURRENT button on the Function switch and desired current range on the Range switch are depressed. The FE149 must be turned on when making AC current measurements. The AC(V/MA) black scales are used. For the 150 microamp, 1.5 Ma, 15 Ma, and 150 Ma ranges, the 0 to 1.5 scale is used. For 150 microamp range, the reading is multiplied by 100 and for the Ma ranges by 1, 10, and 100. For the 500 microamp, 5 Ma, 50 Ma, and 500 Ma ranges the 0 to .5 scale is used. For the 500 microamp range the readings are multiplied by 1000 and for the Ma ranges, by 10, 100, and 1000.

The special 5A jack on the front panel may be used to measure up to 5 amps of AC current. Insert the red test lead supplied in the 5A jack and connect this and the ground lead of the FE149 in series with the circuit. Do not use the probe lead of the FE149 for 5 amp measurements. Depress the 500 Ma Range button and the AC CURRENT button. Read the 0 to .5 AC (V/MA) scale and multiply the readings by 10 to get the actual current in amps. When the FE149 is not being used to measure 5 amps of AC current, the test lead must be removed from the 5A jack. If left in, errors on other readings taken with the FE149 will result.

MEASURING DECIBELS (db): The FE149 has a convenient db scale for easy db measurement. The eight ranges are in perfect 10 db steps for simplicity of measurements. The reference used is 1 milliwatt into 600 ohms for 0 db. Db measurements are actually a ratio of AC voltages or power measurements from a given reference. A 3 db decrease in a voltage would be actually .707 times the original voltage. A 3 db increase would be 1.41 times the original voltage. Because the db ratio cannot always be taken across a 600 ohms load, the chart in Figure 1 allows you to convert the readings taken across different resistive values and correlate them with the 600 ohm reference readings on the FE149 meter. For example, with readings taken across a six ohm resistor +20 db should be added to the meter readings.

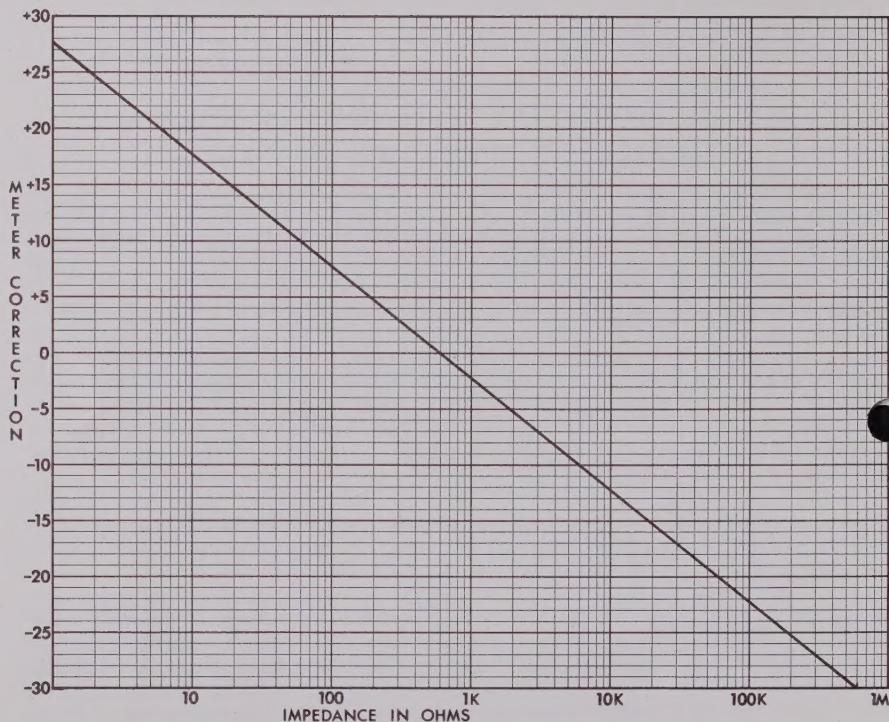


Figure 1

MEASURING EXTREMELY SMALL CURRENTS WITH THE FE149

Very small currents from 0 to 100 nanoamps (0.1 microamps) may be measured using the FE149 in conjunction with a 1.5 volt battery. Leakage currents of transistors and diodes and leakage of paper and electrolytic capacitors can be measured with the method below.

To make nanoamps measurements, depress the plus DC VOLTAGE button and the 1.5 volt range button. Connect a 1.5 volt battery across the input leads; the meter should now read full scale or slightly higher. Connect a transistor, diode or capacitor between one battery terminal and the FE149 input. Observe battery polarity when connecting the device to be measured to obtain an accurate indication. Read the 0 to .5 DC scale of the meter and multiply the reading by 200 to obtain the current in nanoamps. For example:

a germanium diode leakage indication is .48 $.48 \times 200 = 96$ nanoamps
 a silicon diode leakage indication is .1 $.1 \times 200 = 20$ nanoamps

MEASURING HIGH VOLTAGE WITH THE FE149

CAUTION: High voltage is dangerous and extreme caution should be observed when making measurements. Be sure that the ground lead of the FE149 is connected to the ground of the unit to be measured before you measure the high voltage present. If the ground lead is not connected, you are merely extending the high voltage closer

to you. Stand away from the unit you are measuring and keep one hand in your pocket as a safety measure. If you are measuring the high voltage in a color TV receiver, it is especially dangerous because the high voltage supply (often 30,000 volts) is regulated and will not load down to a safe level if you should accidentally come across it.

The optional 39A21 High Voltage Probe is used to extend the DC ranges of the FE149 to 50,000 volts. It contains a 1,485 megohm 3% resistor to give a 100 X multiplier for any range of the FE149. Special ranges of 5KV, 15KV, and 50KV are marked right on the front panel. Do not measure voltages higher than 50KV with the 39A21 High Voltage Probe, as the maximum rating of the resistor is 50KV.

The special high voltage extension for the 39A21 is included with the probe. This extension simply plugs on to the end of the probe and allows the probe to sneak under the rubber caps found on the high voltage connection to the CRT in TV receivers.

Special clips are supplied with the 39A21 that will mount on the back of the FE149 with self tapping screws. These clips will hold the 39A21 High Voltage probe to the FE149 when not in use. Simply mount the clips with the screws provided in the holes in the back of the FE149 case. The 39A21 probe will slip in and out of the clips, but will not be dislodged from the FE149 when it is transported from job to job.

To use the High Voltage probe with the FE149, simply plug the positive test lead from the FE149 into the handle of the 39A21 where it will engage an internal jack. Use sufficient pressure when plugging in to insure that complete contact is made. Connect the ground lead of the FE149 to the unit to be measured, depress the + DC Volts button (- DC if you are measuring a negative high voltage) and the range button of 5KV, 15KV, or 50KV depending upon the voltage to be measured.

To read the actual voltage, multiply the reading on the .5 volt scale by 10K for the 5KV range, the 1.5 volt scale by 10K for the 15KV range and the .5 volts scale by 100K for the 50KV range.

The 39A21 High Voltage probe can also be used to measure voltages of 50, 150, 500, or 1000 volts DC with an input impedance of 1,500 megohms. To obtain this high input impedance, depress the range button of .5, 1.5, 5, or 15 and measure the voltage using the 39A21. Multiply the reading on the meter by 100 to obtain the voltage.

CHECKING THE BATTERIES OF THE FE149

The 9.6 volt rechargeable battery in the FE149 can readily be checked by merely depressing the BATT button on the function switch with the FE149 turned on. If the meter reads in the green area on the lower scale of the meter, the battery is charged to the proper voltage level and the measurements made with the FE149 will be correct. If the meter reads below the green area, the battery is low and should be charged up. To charge up the battery, simply plug the special cord into the FE149 and the other end into a 105 to 125 volt AC source. The OFF-ON switch must be in the ON position and the function switch can be in any position except the BATT position. In this position, the battery is disconnected from the charging source. The battery will be charging at any time the FE149 is turned on and plugged into the power line. The charge circuit will limit the current to prevent overcharge of the battery and any possible damage. The FE149 may be used while the battery charges.

The Ohms battery can be checked by setting the Ohms zero on the RX10 range and then push the RX1 range. If the meter indication falls more than half way into the green "Battery Good" area the ohms battery should be replaced, because readings on low ohms measurements will not be accurate.

REPLACING THE BATTERIES IN THE FE149

The batteries are easy to replace in the FE149. The unit does not have to be removed from its case. Remove the two screws holding the battery door on the rear of the case. This will expose the two batteries. One, a "D" cell, is used for ohms measurement and the other, a 9.6 volt rechargeable battery is used to power the circuit. A

long life high current cell such as the Eveready Alkaline Energizer No. E95 or equivalent is recommended for the ohms battery. A regular type "D" cell can be used, however, but will not last as long, especially if many low ohms measurements are made. The 9.6 volt rechargeable battery is a Burgess CD24 or equivalent.

CHARGING THE BATTERY IN THE FE149

The 9.6 volt rechargeable battery in the FE149 is automatically recharging when the FE149 is turned on and the unit is plugged into a 105 to 125 50-60 Hertz AC source. The special circuit design will not allow the battery to be overcharged, no matter how long it is left charging. When using the FE149 on the bench, it is advisable to always have the meter plugged into the line, so that when you should require portability or wish to make measurements with an isolated meter, the battery will be always fully charged and ready to go. If the FE149 is used as a portable meter on the rechargeable battery, the battery should be recharged after a day's use if at all possible. Periods of operation over 100 hours without recharging the battery should not be attempted as meter accuracy will be affected and also it's hard on the battery. To completely recharge the battery after this period, it should be charged 150 hours. A general rule is to charge 1.5 times the usage period. If the FE149 can be plugged into an AC source and left charging overnight after a day's use, no difficulty should ever be encountered with a run down battery. The battery check on the FE149 is used to tell the condition of the battery and when recharging may be necessary. NOTE: If the FE149 is left in the battery check position, the battery will not charge. In the battery check position, the battery is removed from the charger and a load placed on it to give an accurate check of its condition. The battery will charge in any other position of the Function switch, as long as the unit is plugged in and turned on.

CONVERTING THE FE149 FOR 230 VOLT AC OPERATION

The conversion of the FE149 to 230 volt 50 to 60 Hertz AC operation is simple and easy. The schematic diagram shows the hook up on the special transformer. The brown and white leads are disconnected from their present location, but the blue and black wires remain connected to the same point. Now simply connect the brown and white wires together, solder, and wrap with tape to insulate. The FE149 will now work from 230 volt 50 to 60 Hertz AC or the internal battery.

OVERLOAD PROTECTION ON THE FE149

The FE149 is completely protected from accidental overloads or the application of wrong voltages so that damage to the FE149 is prevented if a mistake is made in measurements. Four different types of protection are incorporated in the FE149. Transistors connected as diodes protect the field effect transistors and circuitry from damage by excessive input voltages. The meter is protected from excessive current by a pair of diodes; The diodes conduct and shunt the excessive current around the meter. A one amp fuse protects the current and ohms functions of the FE149. A special spark gap is also included on the ohms function to protect the switch from input voltages. If the excessive current or voltage is left on for an extended period of time, the fuse will blow and open the circuit. If an A voltage of several hundred volts is applied to the ohms ranges, the spark gap will limit the voltage and prevent damage to the switch after the fuse blows. This prevents accidental application of voltage to the ohms ranges from burning out an ohms resistor in the FE149. When the fuse is blown, only the current and ohms functions of the FE149 will be inoperative; The voltage scales can be used to measure voltage. Two spare fuses are included with the FE149 and can be found in the fuse holder mounted on the inside of the battery door. When replacing the fuses, be sure to use a low resistance type fuse such as the Littlefuse 312001 one amp fast blow. A fuse with a high internal resistance will upset the low ohms ranges and give inaccurate readings.

DISASSEMBLY INSTRUCTIONS

If the FE149 is to be removed from its case for service or recalibration, the battery door must be removed first. To do this, remove the two screws holding this door on the back of the case. Then remove the four screws holding the front panel to the case, two on the bottom of the panel and two on the back of the case. Tilt the top forward slightly and pull the panel from the case. This will expose the PC boards and chassis for calibration or service. Generally, no further dismantling is necessary for service work, as the bottom of the circuit board is accessible and the circuit board on the bottom holds only the range resistors. All the calibration controls will be found on the top board with the exception of the low ohms cal control which is on the range board.

If it should be necessary to separate the two boards for parts access, remove the phillips screws holding the range PC board. Push the range assembly sideways until the push knobs will clear the edge of the panel on one side, then slide the assembly to the opposite side until it is free of the panel. The assembly can then be moved for best convenience.

To reassemble the FE149, simply reverse the procedure.

CALIBRATING THE FE149

The FE149 can be recalibrated quickly and easily if and when it becomes necessary. First, remove the unit from its case. See DISASSEMBLY INSTRUCTIONS. This will expose the two printed boards and the calibration controls. If a complete recalibration is to be done, follow the steps in the order below. If only a touch up of the AC or DC ranges is to be made, be sure to check the AC and DC balance. Calibration is affected if balance is off. As a preliminary to any calibration, set the mechanical zero on the meter to zero. Do this when the meter is in normal operating position and set up for 500 milliamps DC current test.

DC BALANCE: Depress the plus DC volts Function button and the 1500 volt Range button and slide the power switch to on. (No difference will be noted if the FE149 is operated from the AC line or battery unless the battery is down. To check the battery, simply depress the BATT button on the Function switch and read the battery condition

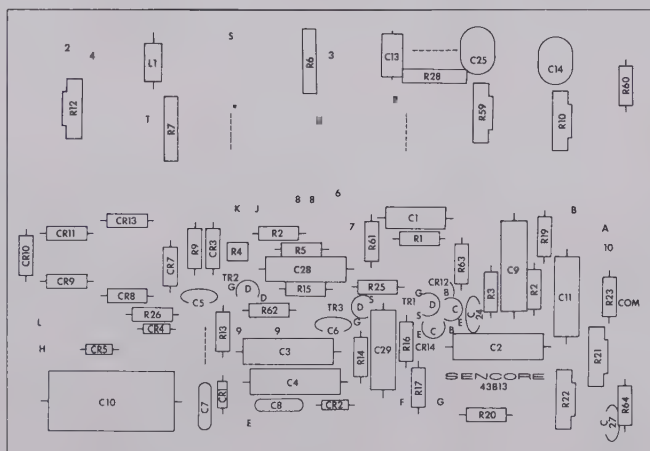


Figure 2

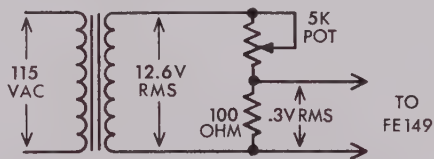
on the lower scale of the meter. If the battery indicates below the green area, recharge the battery or calibrate the FE149 using AC power). Set the front panel ZERO ADJ fully clockwise and adjust R21, the DC balance control, for a reading of .3 on the .5 scale of the meter. See Figure 2 for the location of R21 and the other calibration controls. Set the front panel ZERO ADJ for zero on the left side of the meter. Depress alternately the plus and minus DC volts buttons on the Function switch. The meter needle should move only slightly, if at all.

AC BALANCE: After setting the DC balance, depress the AC volts button and adjust R22, the AC balance control for a zero indication on the left side of the meter. Depressing the plus DC volts and AC volts buttons alternately should produce very little meter deflection.

DC VOLTS: The DC voltage ranges can be calibrated using an accurate .5 volt source and adjusting R10 located directly behind the plus DC volts push button for a full scale meter deflection. If an accurate .5 volt source is not available, a fresh 1.5 volt battery may be used. Depress the plus DC volts Function button and the 1.5 volt Range button. Connect the battery to the input of the FE149 and adjust R10 for a reading of 1.55 volts on the 1.5 volt scale of the meter.

AC VOLTS: To calibrate the AC ranges, an accurate .5 volts RMS sine wave is recommended. With the AC voltage applied, R59, found directly behind the AC volts push button is adjusted for a full scale meter deflection on the .5 volt range. If an accurate AC voltage source is not available, you may use a 12.6 volt filament transformer or the 117 volt AC line. Depress the proper range button, 15 if you are using a 12.6 volt source or the 150 volt range if you are using the AC line and adjust R59 for the proper meter indication.

AC CURRENT: The AC current ranges of the FE149 can be calibrated using a known source of AC current. An alternate method is to apply a .3 volts RMS AC voltage from a low impedance source to the input with the FE149 set up for 150 microamp AC current range. A .3 volt signal will give a full scale deflection of 150 microamps on the meter. R12, located directly behind the AC current Function button is used to adjust the AC current ranges of the FE149. To obtain the .3 volt RMS AC signal use the circuit below. The pot is adjusted until the FE149 reads .3 volts on the AC scale of the meter. Then depress the AC current Function button and the 150 microamp range button and adjust R12 for 150 microamp reading on the meter.



LOW OHMS CAL:

Figure 3

Battery impedance, switch and battery contact resistance, resistance of the test leads etc., all affect meter accuracy on low ohms measurement. The FE149 has a special adjustment, the low ohms cal, which is used to calibrate the mid scale of the low ohms range. Before this control is reset, a new battery should be installed. Set the function switch in OHMS and the RANGE switch in RX1 position. Adjust the meter for a full scale deflection or 0 (zero) ohms with the ohms adjust control. Unshort the leads to be sure they return to zero at the left hand side of the meter. Now, using a precision 6 ohms resistor applied to the input, adjust the low ohms cal (found on the range switch board on the lower right hand corner) until the meter reads 6. If a 6 ohms resistor is not available, a 5ohm unit will work. The tolerance of the re-

sistor used to calibrate the low ohms scale will, of course, affect the tolerance or accuracy of the low ohms readings.

NOTE: If a high resistance fuse is used in place of the low resistance type recommended, the low ohms scale will be effected, and the low ohms cal would have to be readjusted.

CIRCUIT DESCRIPTION FOR THE FE149

The Sencore FE149 is the ultimate in field effect meters and uses the FET to achieve the high input impedance with a differential amplifier system to provide the utmost in stability and accuracy. The push button switches select the mode or function of the amplifier system and the range of resistance for the proper measurement. The FE149 employs two printed boards to make servicing easier. The large board on the top near the meter contains the FET amplifiers and function switch. The bottom board contains the range switch and all of the range resistors.

When the plus or minus DC VOLTS button is depressed, FET's TR1 and TR2 (See schematic Figure 5) form a differential amplifier with the meter in the source. The DC BAL control and ZERO ADJ set the amplifier up so that with no input, the current through the FET's are equal and no current flows through the meter. When a DC voltage is applied to the input, it is applied across the voltage divider consisting of R43 to R50. The range switch is depressed and selects one of the points so that the voltage applied to the gate of TR1 is .4 volts or less to cause the meter to read full scale. If an excessive voltage is applied to the input, say the 5 volt range is depressed and 1500 volts is applied, then diodes CR12 and CR14 will conduct and keep the voltage at the gate and source of TR1 from reaching breakdown. The voltage that does appear at the gate will be about only one-fifth of the breakdown voltage and the meter will only be overloaded about 2 to 3 times so that no damage will result.

When the OHMS function is depressed, TR1 and TR2 are again used as a differential amplifier. The unknown resistor is placed in series with the standard resistor R52 through R58 by the range switch. R51 is used to calibrate R52 for an exact 6 ohms center scale on the low range. F1 is in series with the unknown and standard resistor so that in case excessive voltage is applied to the ohms ranges, the fuse will blow to protect the resistors. The voltage developed across the standard resistor is proportional to the unknown resistor. This is applied to the gate of TR1 through R32, R33 and R34. This divider divides the voltage to the gate so that full scale deflection will occur at .4 volts. Also, as the ranges are changed from RX10 meg and down, the zero ohms adjust changes very little, eliminating time consuming re-zeroing of the meter.

In DC volts and OHMS, TR3 has no function and is inoperative at this time.

When the AC VOLTS button is depressed, TR2 and TR3 become the differential amplifier and TR1 becomes a source follower. The AC voltage is applied through the voltage divider as before to the gate of TR1.

The AC voltage from TR1 is applied through C3 to the peak to peak detector CR1 and CR2. The detected output is applied to the gates and is the result of the actual peak to peak voltage of the input AC signal. The resultant unbalanced DC voltage causes the meter in the source circuit of TR2 and TR3 to read. If excessive voltage is applied to the input as in DC, diodes CR12 and CR14 will again conduct and protect the input transistor TR1. The control R22 is set up so that with no AC voltage applied to the input, the gates of the transistors are balanced with equal currents through the FET's so that the meter reads zero. This compensates for any unequal leakages and components in the circuit.

The AC current ranges use the same amplifier system as used for AC voltage. The FE149 is connected in series with the circuit where the AC current is to be measured.

The range switch selects the resistors R35 to R42. The voltage drop across this resistor is coupled to the input transistor TR1. The range resistors are selected so that a .3 volt RMS signal will cause full scale meter deflection. The current from the circuit will cause a voltage drop and the resultant drop is then measured and converted into current on the meter scale. When measuring DC current, the FE149 can be turned off as the FET's are not used. The meter is placed in the circuit with the proper shunt resistor R35 to R42 selected by the range switch. The meter is protected from overload by the diodes CR7 to CR11 and CR13. With excessive current, the voltage drop across the meter increases, and the diodes conduct, shunting the excessive current around the meter. If the meter is left in the circuit too long, or the excessive current is extreme, the fuse F1 will blow, opening the circuit. When F1 blows, both the ohms and current functions will be inoperative.

The power supply for the FE149 circuits can be either a rechargeable battery or the AC line. The power supply for the AC line and also for recharging of the rechargeable battery consists of a half wave rectifier CR5 and a power transformer to isolate the FE149 from the AC line. Transformer T1 can be used to operate from 115 VAC or 230 VAC by simply changing the internal connections. The pulsating DC is filtered by C10. The zener diode CR4 provides further filtering and regulates the voltage to approximately 12 volts so that regardless of line voltage changes, the supply voltage to the FET circuit is constant and also prevents overcharging of the rechargeable battery. Diode CR3 prevents the battery from discharging back through the zener diode when the FE149 is not plugged into an AC outlet. The AC line cord is a three conductor type and puts the case of the FE149 at ground potential as recommended by UL. No fuse is used in the primary of the power transformer as the impedance of the circuit is high and the maximum current, even from a shorted component will not damage the unit.

TROUBLE CHART

<u>SYMPTOM</u>	<u>PROBABLE CAUSE</u>	<u>CORRECTIVE MEASURE</u>
Unit dead on ohms and current functions	Blown fuse	Replace fuse - Be sure to use low resistance type specified
Cannot adjust ohms ADJ to full scale on RX1 range	Poor contact on 1.5 volt battery, 1.5 volt battery weak	Check contacts, replace battery
Measurements inaccurate on RX10 meg range	Some leakage in circuits, wiring or components	Adjust meter zero on RX1 meg range then depress RX10 meg. If meter reads slightly up scale 1/8 to 1/4 inch it is an indication of normal circuit leakage. More than this is abnormal and circuit should be checked out.
Incorrect readings on different ranges	Diode CR12 or CR14 leaky FET TR1 leaky	Replace diode Replace FET (specify color when ordering)
DC voltage readings inaccurate	Unit improperly calibrated	Check and recalibrate per calibration instructions in manual.

<u>SYMPTOM</u>	<u>PROBABLE CAUSE</u>	<u>CORRECTIVE MEASURE</u>
Cannot zero meter; meter reads past full Scale on DC volts	Open resistor or circuit to gate of TR1 or TR2 or TR1 is defective	Place temporary jumper between terminals 6 and 10 on large PC board. If meter can now be zeroed, open exists in resistors R43 to R50 or wiring on small PC board. Check small PC board with ohmmeter. If meter cannot be zeroed with jumper, R1, CR12, C26 or TR1 are defective. Check CR12 and C26 for short, or R1 for open. Replace TR1 if necessary. (Specify color when ordering)
Zero adjust requires frequent adjustment	Battery voltage dropping	Operate from power line for several hours to charge battery to normal voltage.
Rechargeable battery runs down	Charging circuit not functioning	Check voltage at CR4. Replace defective CR4, R26, C10, CR5, T1, S3, or line cord, if voltage is low or missing.
	CR3 leaky	Replace CR3
	Battery defective and will not hold a charge	Check battery and replace if it will not hold a charge
Cannot make measure- ment on one current range.	Poor connection to switch or resistor on this range Open resistor	Check connections Replace open resistor
Inaccurate readings one one current range	Resistor value changed	Check resistor value or range in question and replace resistor if off value.
Inaccurate readings on one ohms range	Resistor value changed	Check resistor value on range in question and replace resistor if off value. In RX1 ohms range, check and if necessary, adjust Lo ohms cal control
Push buttons stick or refuse to push in	Foreign material or particles around moving arm of button	Remove unit from case and clean inoperative button and lubricate with a good tuner cleaner with silicone such as "Blue Stuff" or "Super Wissh with Silicone".

FE149 PARTS LIST

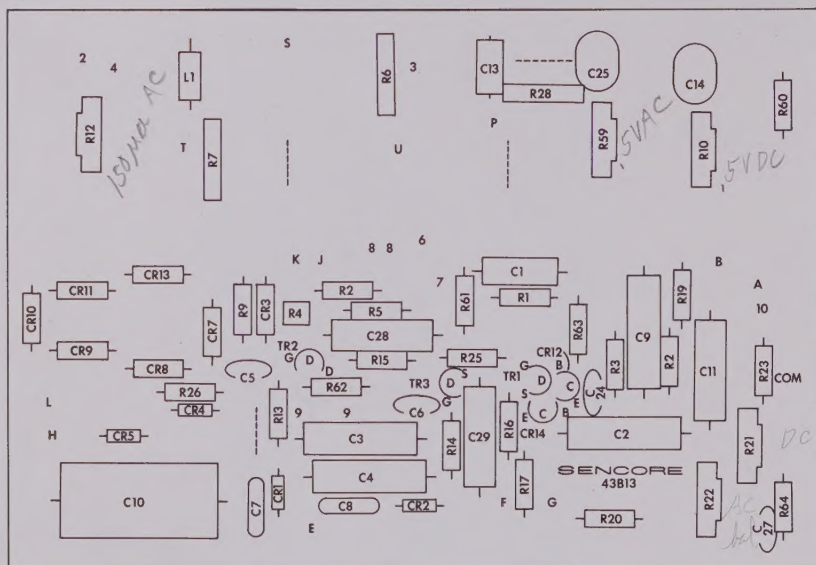
<u>REFERENCE NO.</u>	<u>PART NO.</u>	<u>DESCRIPTION</u>	<u>PRICE</u>
CR1, CR2	19G28A	Diode, Germanium	\$.50
CR3, CR6, CR7	16S5	Diode, Rectifier	
CR8, CR9, CR10	"	.5A @ 400 VPIV	1.50
CR11	"		
CR4	50G7	Diode, Zener 12 V @5%	1.95
CR5	19G13	Diode, IN34A	.50
CR12, CR14	19G27	2N5172 Transistor	
M1	SC23C28	7" Meter, 100 Microamp, 1.9K	35.00
R2	14G278	5.1K 1/2W 5%	.30
R4	14G305	Thermistor 5K Cold	.75
R6	14G301	3K 1/2W 1%	.75
R7	14G307	1.1K 1/2W 2%	.75
R9	14G302	110K 1/2W 5%	.30
R27	14G163	2.2K 1/2W 5%	.30
R28	14G279	3Meg 1/2W 1%	.75
R29	14G324	.089 Ohm Wire	.75
R32, R33, R34	14G300	20 Meg 1/2W 5%	.30
R35	14G294	5.15K 1/2W 1%	.75
R36	14G295	750 OHM 1/2W 1%	.75
R37	14G296	203 OHM 1/2W 1%	.75
R38	14G297	61.2 OHM 1/2W 1%	.75
R39	14G298	19.1 OHM 1/2W 1%	.75
R40	14G299	6 OHM 1/2W 1%	.75
R41	14G303	1.9 OHM 1/2W 1%	.75
R42	14G304	.57 Ohm wire	.75
R43	14G280	8.2 Meg 1W 1/2%	1.25
R44	14G281	2.6 Meg 1/2W 1/2%	1.25
R45	14G282	820K 1/2W 1/2%	1.25
R46	14G283	260K 1/2W 1/2%	1.25
R47	14G284	82K 1/2W 1/2%	1.25
R48	14G285	26K 1/2W 1/2%	1.25
R49	14G286	8.2K 1/2W 1/2%	1.25
R50	14G287	3.8K 1/2W 1/2%	1.25
R52	14G288	7 OHM 3W 10%	.50
R53	14G289	59.3 OHM 1/2W 1%	.75
R54	14G290	600 OHM 1/2W 1%	.75
R55	14G291	6K 1/2W 1%	.75
R56	14G292	60K 1/2W 1%	.75
R57	14G293	606K 1/2W 1%	.75
R58	14G272	6.67 Meg 1/2W 1%	.75
R10	15G54	500 OHM Control PC Vert Mount	.75
R11, R18	15A33	10K Control	1.
R12, R59	15G61	5K Control PC Vert Mount	.75
R21, R22	15A53	10K Control PC Vert Mount	.75
R51	15G77	100 OHM Control PC Vert Mount	.75

<u>REFERENCE NO.</u>	<u>PART NO.</u>	<u>DESCRIPTION</u>	<u>PRICE</u>
TR1, TR2, TR3	19G30	Transistor (FET) 2N5163 (Specify Color when ordering)	1.50
C1	24G141	560PF 125V Poly 5%	.25
C2, C3, C4, C9	24G146	.47 MF 200V Mylar 5%	.60
C11	24G120	10MF 15V Lytic	
C13	24G190	180PF 500V Poly 5%	.25
C16	24G189A	36PF 1000V Disc 5%	.25
C17	24G187	91PF 630V Poly 2 1/2%	.25
C18	24G186	330PF 160V Poly 2 1/2%	.25
C19	24G188	.001 MF 33V Poly 5%	.25
C20	24G182	3300 PF 33V Poly 5%	.25
C21	24G183	.01 MF 33V Poly 5%	.25
C22	24G184	.033 MF 63V Mylar 5%	.35
C23	24G185	.071 MF 33V Poly 5%	.75
C24	24G199	62PF 33V Poly 5%	.25
T1	28A35B	Power Transformer	4.50
J1	26A78	5 AMP 2 Conductor Jack	.50
S1	25B111	Push Switch Range	14.50
S2	25B112	Push Switch Function	15.50
	11G9	Battery Snap Connector Female	.25
	11G10	Battery Snap Connector Male	.25
		Battery Plate Complete	1.25
	SC8A10	Escutcheon, Switch	2.25
		Case Complete	11.25
		Burgess CD24 Rechargeable battery for FE149 (Not Supplied with unit)	9.95

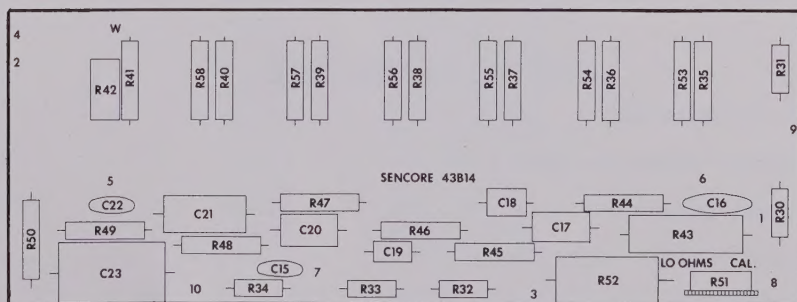
(PRICES SUBJECT TO CHANGE WITHOUT NOTICE)

ITEMS INCLUDED WITH FE149

- 1 - Instruction Manual
- 1 - Warranty registration card
- 1 - Three prong line cord
- 1 - 5 Amp test lead
- 2 - 1 Amp fast blow fuses (located inside battery door)



FUNCTION CIRCUIT BOARD



RANGE CIRCUIT BOARD

Figure 4



You have just purchased one of the finest field effect voltmeters on the market today. The FE149 has been inspected and tested twice at the factory to insure the best quality instrument to you. If something should happen, the FE149 is covered by a standard 90 day warranty as explained on the warranty policy enclosed with your instrument.

For the best service on out of warranty work, send the Field Effect Meter directly to the factory service department. Be sure to state the nature of your problem to insure faster service.

If you wish to repair your own Field Effect Meter, we have included a schematic, parts list, and trouble chart. Any of these parts may be ordered directly from the factory service department.

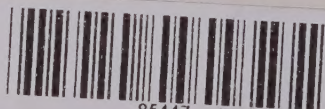
We reserve the right to examine defective components before an in warranty replacement part is issued.

If the rechargeable battery is allowed to drop to an extremely low voltage, such as mid scale or less, it will affect the readings taken with the FE149. Be sure to allow the battery to charge till the meter reads near the battery check point before using the FE149 to take voltage or resistance readings. If the rechargeable battery is allowed to remain in a very low condition, it may become permanently damaged. Be sure to recharge the battery as soon as possible after it falls below the green battery check area on the meter when the BATT button is depressed. Refer to page 10 under "CHARGING THE BATTERY IN THE FE149" for more information on recharging of the battery.



NO. 1 MANUFACTURER OF ELECTRONIC MAINTENANCE EQUIPMENT

426 SOUTH WESTGATE DRIVE, ADDISON, ILLINOIS 60101



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